Advantages of Electromagnetic Diagnostics of Traction Asynchronous Motors of Electric Locomotives

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Annotation: Based on a comparative analysis of existing test and functional methods of technical diagnostics, it is advisable to use functional diagnostic methods in assessing the technical condition of traction asynchronous motors. From a brief comparative analysis of thermal, electrical, vibroacoustic and magnetic methods of functional diagnostics, it follows that each method has its own characteristics, advantages and disadvantages; each method does not have the possibility for a sufficiently accurate and complete diagnosis of the technical condition of the TAM. Therefore, in addition to improving these methods, it is worth using them together with sufficient accuracy and thoroughness to diagnose the technical condition of the TAM.

Keywords: asynchronous motor, stator, rotor, functional diagnostics, electromagnetic method, vibroacoustics, external magnetic field.

INTRODUCTION

The locomotive fleet of Uzbekistan Railways is being renewed and enriched with modern locomotives. Electric locomotives of the series "Uzbekistan", "Uzbekistan" -Y, Uz-EL, Uz-ELR, 2O‘z-UY are equipped with asynchronous motors, which help to generate large traction. Traction asynchronous motors (TAM) are very reliable compared to fixed traction electric motors and, despite their long service life, are not free from various defects and malfunctions. Factors that contribute to the occurrence of defects and malfunctions in TAMs include environmental impact, manufacturing and repair errors, various dynamic effects, and cases of misuse. Local and international experience shows that the introduction of diagnostic tools is one of the most important factors in improving the economic efficiency of locomotives. The purpose of diagnostics is to identify and prevent defects and malfunctions, to maintain operational performance within the established limits, to forecast the situation for the full use of the resource [1].

Different loads have a significant impact on the performance of electric locomotives TAMs. When using TAMs, the current of the traction motor, as well as its rotational frequency, changes every minute (Figure 1).

TAM electric locomotives will be installed at the bottom of the carriages. This affects its overall dimensions and design, as well as the type of suspension of the traction motor in the carriage.

The following factors are the main causes of faults in electric locomotives TAM:

- sudden changes in ambient temperature and humidity;
- operation of TAM in different operating modes (short-term, recurrent short-term);

- the presence of mechanical effects on electric motors during acceleration or stopping the train. Working in dry and hot climates, TAMs worsen the cooling conditions, leading to its dusting, which in turn leads to the drying and acceleration of the insulation materials [13]. High humidity (during snow or rain) reduces the volume and surface resistance of the insulation, leading to accelerated corrosion of metal parts [13].

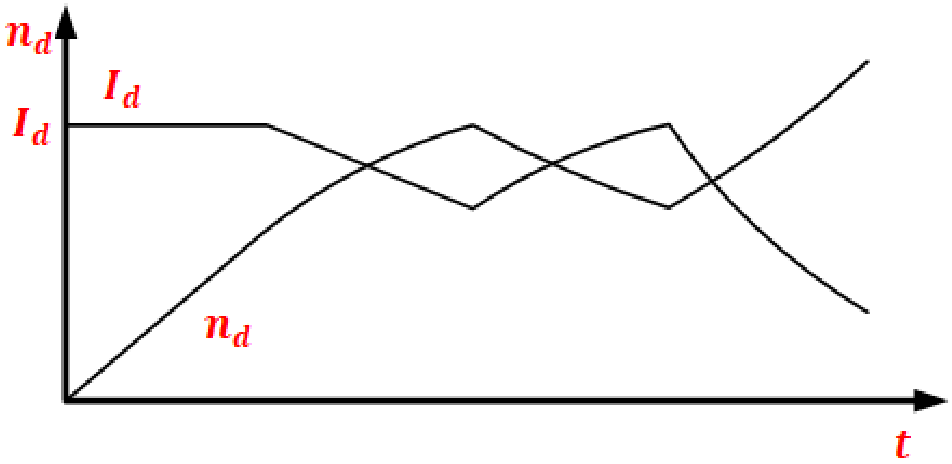


Figure 1. Graphs of time (*t*) of current (I_d) and rotational frequency (n_d) consumed during operation of an electric locomotive asynchronous motor

Analysis of technical condition testing and functional diagnostic methods of TAMs.

Modern systems and methods of diagnosing TAM can be divided into two groups [2]. The first group includes test-based diagnostic methods. These methods measure the insulation resistance, the angle of the dielectric loss tangent in it, the currents flowing from the insulation to the housing, the internal resistance of the coils, and so on. However, such a diagnosis not only prevents the development of various defects, but also their occurrence. For example, during routine maintenance of TAMs, after complete assembly, the motor is tested under high voltage, which has a detrimental effect on the motor insulation. Overloads, frequent start-ups and shutdowns can also lead to the development of microdefects that develop in the tires during TAM operation. In addition, the shortcomings of test-based diagnostics include the temporary suspension of the operation of the TAM, the inability to protect the engine during its operation to prevent its complete failure, control of abnormal operating modes of this equipment and other circumstances [3].

The second group includes functional diagnostic methods. They are the most economical because they do not require a temporary shutdown of electrical equipment. In order to prepare for repairs, it is necessary to identify all the defects that affect the resource long before the breakdown. In this regard, it is necessary to use diagnostic methods that not only fall into the functional category, but also allow to identify a defect in a particular part of the TAM[4].

Methods of functional diagnosis of TAM

Currently, the following methods of functional diagnostics of asynchronous motors are common: heat; electricity; vibroacoustic; magnetic.

The thermal method determines the parameters of thermal processes occurring in TAMs due to electromagnetic processes, such as the temperature of the stator groove, rotor rods, magnetic conductors and other parts, or the temperature in other parts or the heat radiation radiated from them is determined. Characteristic points for measurement were selected based

on the structural properties of the TAM elements and the location of the areas of heat generation in them[5]. The disadvantages of this method are the complexity of diagnosing the technical condition of TAM moving parts and selecting the optimal mode of thermal control and the inability to monitor the internal damage of the insulation of TAMs.

Electrical method TAM stator current change; deviation of amplitude and frequency of voltages from nominal values; based on the detection and analysis of the occurrence of high harmonics in the spectrum of currents, voltages, etc. [6]. The method is based on the presence of intermediate short circuits in the stator windings and damage to the rotor (broken rods, weakening of the rods to the contact rings, hidden defects in the casting), improper installation of the motor shaft, eccentricity, loosening of fasteners, mechanical part of TAM allows the detection of related defects.

The vibroacoustic diagnostic method determines the vibration parameters of TAM. The specific characteristics of the diagnostic object are used as a reference and are measured at the initial stage of operation. Using this method, it is possible to analyze low-frequency spectra and determine the coherence function associated with rotor speed and their bending, the bending of body parts, rotor imbalance, defects in bearings and other defects. The main disadvantages of vibroacoustic diagnostics are the need to use special vibroacoustic sensors, the complexity of their installation and the difficulty of analyzing the results, as well as the fact that low-voltage motors are not sufficiently sensitive to electrical damage[8].

The method of magnetic functional diagnostics is based on the control and analysis of the parameters of the working magnetic field in the TAM working air gap and the scattered (external) magnetic field that merges through its outer side [9].

The essence of the method based on the control of the parameters of the external magnetic field TAM is that the current or induction of the magnetic field scattered on the outside of the running motor is measured using touch measuring instruments. The signal from the meter is transmitted to a computer, digitized and recorded. Spectral analysis of the received signals is carried out with the help of the analyzer and the type and location of the fault is determined depending on the results[10].

This method can be used to diagnose stator windings, phase outages, bearing failures, static and dynamic eccentricities in the rotor [11]. Based on the analysis of the external magnetic field, the accuracy of the results obtained using this magnetic method is 92% [12].

Conclusion: Based on a comparative analysis of existing test and functional methods of technical diagnostics, it is advisable to use functional diagnostic methods in assessing the technical condition of traction asynchronous motors. From a brief comparative analysis of thermal, electrical, vibroacoustic and magnetic functional diagnostic methods, each method has its own characteristics, advantages and disadvantages, with a separate one of which it is not possible to diagnose TAM technical condition with sufficient accuracy and completeness. Therefore, in addition to improving these methods, it is advisable to use them together with sufficient accuracy and complete diagnostics of the TAM technical condition.

BIBLIOGRAPHY

1. Ширман А.Р., Соловьев А.Б. Практическая вибродиагностика и мониторинг состояния механического оборудования. – М., 1996. – 276 с.
2. Бигус Г. А. и др. Основы диагностики технических устройств и сооружений. – 2015.
3. Сидельников Л. Г., Афанасьев Д. О. Обзор методов контроля технического состояния асинхронных двигателей в процессе эксплуатации //Вестник Пермского

национального исследовательского политехнического университета. Геология, нефтегазовое и горное дело. – 2013. – №. 7. – С. 127-137.

4. Пономарев В.А., Суворов И.Ф. Комплексный метод диагностики асинхронных электродвигателей на основе использования искусственных нейронных сетей // Новости электротехники. – 2011. – № 2 (68).
5. Исмагилов Ф.Р., Хайруллин И.Х., Пашали Д.Ю., Бойкова О.А. Обзор современных методов и средств оперативной диагностики электромеханических преобразователей энергии // Вестник УГАТУ: «Энергетика, электрификация и энергетическое машиностроение», Уфа, 2010. – Т. 14, № 4 (39). – С. 73–79.
6. Петухов В. С. Диагностика состояния электродвигателей. Спектральный анализ модулей векторов Парка напряжения и тока // Новости электротехники. 2008. № 49. С. 50–52
7. Лопатин А. С. Обоснование диагностических признаков дисбаланса роторов // Вибродиагностика для начинающих и специалистов: [2007] URL: http://www.vibration.ru/disb_rot.shtml (дата обращения 20.12.2009).
8. Тонких В.Г. Метод диагностики асинхронных электродвигателей в сельском хозяйстве на основе анализа их внешнего магнитного поля. – Барнаул, 2009. – 181 с.
9. Амиров С., Авезова Н., Файзуллаев Ж. Диагностические-математические модели тяговых асинхронных двигателей //Транспорт Шёлкового Пути. – С. 49.
10. Yakubov M. S. et al. Methodological aspects of continuous controlling and diagnostics traction electrical equipments using methods of spectral analysis //Chemical Technology, Control and Management. – 2018. – Т. 2018. – №. 1. – С. 85-90.
11. Бойкова О.А. Функциональная диагноистика неисправностей электромеханических элементов электротехнических комплексов по внешему электромагнитному полю дис. ... канд. техн. наук: 05.09.03. Уфа, УГАТУ, 2009. - 150 с.
12. Пашали Д.Ю. Диагностика электромеханических преобразователей по внешнему магнитному полю: дисс. ... к.т.н., Уфа, УГАТУ, 2004. -182 с.
13. Дорохина Е. С. Мониторинг теплового состояния асинхронных тяговых электродвигателей: диссертация на соискание ученой степени кандидата технических наук: спец. 05.09. 01 : дис. – 2015.